

NASA TECH BRIEF



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Axisymmetric Reacting Gas Nonequilibrium Performance Program

The problem:

To develop an axisymmetric method for calculating the kinetic performance of propellant systems having gaseous exhaust products containing the elements carbon, hydrogen, oxygen, nitrogen, fluorine, and chlorine.

The solution:

A computer program which calculates the inviscid axisymmetric nonequilibrium nozzle expansion of gaseous propellant exhaust mixtures containing the six elements.

How it's done:

The computer program considers the 19 significant gaseous species present in the exhaust mixtures of propellants containing the above elements and the 48 chemical reactions (13 dissociation-recombination reactions and 35 binary exchange reactions) which can occur between the exhaust products. On option, the program calculates either the expansion of a uniform mixture (the ideal engine case) or of a two-zone mixture (the film cooled engine case). The initial data line required to start the characteristic calculations is obtained from an appropriate transonic analysis. The characteristic equations governing the fluid dynamics variables are integrated using a second order (modified Euler) explicit integration method while the chemical relaxation equations are integrated using a first order implicit integration method to insure numerical stability in near equilibrium flows.

This program is completely self-contained, requiring specification of only the propellant system (elemental composition and heat of formation), relaxation rates, and nozzle geometry to run a case. The chemical species considered have been selected to allow accurate equilibrium, frozen and kinetic per-

formance analyses of cryogenic, space storable, pre-packages, hybrid and solid propellant systems of current and projected operational use. This program allows analysis of the performance loss associated with film cooling in propellant systems having all gaseous exhaust products. It also allows simultaneous consideration of both chemical and gas-particle relaxation losses in propellant systems having condensed exhaust products. This program is designed for engineering use and is specified and programmed in a straightforward manner to facilitate its use as a development tool.

Notes:

1. This program is written in Fortran IV for use on the IBM 7094 computer.
2. This program will perform calculations for contoured nozzles as well as conical nozzles.
3. Related computer programs are described in NASA Tech Briefs 68-10374, 68-10375, and 68-10376.
4. Inquiries concerning this program may be directed to:

COSMIC
Computer Center
University of Georgia
Athens, Georgia 30601
Reference: B68-10377

Patent status:

No patent action is contemplated by NASA.

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